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Anuran Community Monitoring at Congaree National Park

2014 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2015/988



On the cover:
Cope's gray treefrog (*Hyla chrysoscelis*)
Photograph by: Briana Smrekar

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. Data in this report were collected and analyzed using methods based on established peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Executive Summary

The southern United States hosts one of the most diverse amphibian communities in the world and supports the highest density of amphibian species in North America (Echternacht and Harris 1993). The South contains 63 species of frogs and toads, 11 of which are endemic; this accounts for almost 40% of the total number of anuran species in the United States (Dorcas and Gibbons 2008, Echternacht and Harris 1993). The park units in the National Park Service (NPS) Southeast Coast Network (SECN) are home to 35 known anuran species (frogs and toads). Given their known population declines, sensitivity to anthropogenic stressors, and the diversity of amphibians in the southeastern United States, anuran communities are a priority for SECN monitoring efforts. This report summarizes anuran community vital signs monitoring data collected at Congaree National Park (CONG) in 2014.

- Automated recording devices were used to collect recordings from 3/21/2014 through 6/19/2014 at 22 spatially balanced random locations.
- Vocalizations from 13 anuran species were identified.
- A total of 164 vocalizations were detected on the recordings. Each detection represents an identifiable observation of a species or species group during one night of monitoring at a sampling location.
- The Cope's gray treefrog (*Hyla chrysoscelis*) had the highest frequency of occurrence at CONG in 2014; the southern toad (*Anaxyrus terrestris*) and southern leopard frog (*Lithobates sphenocephalus*) had the second-highest naïve occupancy rates.
- The southern toad had the highest relative frequency of detection of anuran vocalizations over the 77-day recording period.
- Southern toad, Cope's gray treefrog, and southern leopard frog were the most widely distributed species at CONG in 2014.
- No non-native species were found.
- Anuran communities will next be sampled in 2017.
- The full dataset and associated metadata can be acquired from the NPS Integrated Resource Management Applications (IRMA) portal at http://irma.nps.gov.

Introduction

Overview

Amphibian populations have declined in North America and many other areas around the world. Several factors have contributed to these population declines and localized extinctions. Among these factors are disease and anthropogenic stressors, such as habitat loss and degradation, non-native predators, acid precipitation, altered hydrology and hydroperiod, ultraviolet radiation, and chemical contaminants (Collins and Storfer 2003). Although diseases and parasites naturally occur in amphibian populations, their effects can be exacerbated when combined with other anthropogenic stressors.

Amphibians have complex life cycles in which the immature phase often consists of an aquatic larval stage, followed by a post-metamorphic adult terrestrial stage. Slight alterations in the aquatic or terrestrial communities upon which amphibians depend can substantially impact the survival, reproduction, and persistence of a species. Given their habitat requirements, anatomy, and physiology, amphibians are considered good indicators of ecological condition.

The southern United States hosts one of the most diverse amphibian communities in the world and supports the highest density of amphibian species in North America (Echternacht and Harris 1993). The South is home to 63 species of frogs and toads, 11 of which are endemic; this accounts for almost 40% of the total number of anuran species in the Unites States (Dorcas and Gibbons 2008, Echternacht and Harris 1993). Units in the National Park Service (NPS) Southeast Coast Network (SECN) have 35 known anuran species (frogs and toads). Given their known population declines, sensitivity to anthropogenic stressors, and the diversity of amphibians in the southeastern United States, anuran communities are a priority for SECN monitoring efforts.

The National Park Service Omnibus Management Act of 1998, and other reinforcing policies and regulations, require park managers "to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources" (Title II, Sec. 204). The anuran community monitoring data summarized herein is a tool to assist park managers in fulfilling this mandate.

This report summarizes data collected as a part of the Southeast Coast Network Vital Signs Monitoring Program's efforts to assess the status and trends of anuran communities at Congaree National Park (CONG, or Congaree).



Southern leopard frog. Photo by Briana Smrekar.

Study Area

Congaree National Park is situated adjacent to the Congaree and Wateree Rivers in southeast Richland County, South Carolina, approximately 20 miles downstream of the capital city of Columbia (Figure 1). Encompassing 25,300 acres, Congaree protects old-growth trees and diverse plant and animal life within the largest intact expanse of old-growth bottomland hardwood forest remaining in the United States. Periodic flood waters from the adjacent rivers flow through the bottomland forest in winter and spring, carrying nutrients and sediments that nourish and rejuvenate this unique floodplain ecosystem. Nearly 90 species of trees grow within Congaree National Park, including many that are recognized as national and state champions for their size. Forested wetlands, oxbow lakes, and slow-moving creeks and sloughs provide habitat for fish, birds, reptiles, mammals, and other aquatic life. The diversity of flora and fauna, tall tree canopy, champion trees, and intact floodplain ecosystem earned Congaree National Park the designations of International Biosphere Reserve, National Natural Landmark, Globally Important Bird Area, and congressionally designated Wilderness Area.

A wide variety of forest communities are represented at Congaree, with dominant tree species ranging from upland pines (*Pinus* spp.) to wetland cypress (*Taxodium* spp.) and tupelo (*Nyssa* spp.). The Congaree River floodplain is characterized by silty clay soils, oxbow lakes, swales and sloughs, and meandering creeks. The Congaree and Wateree Rivers are the major source of floodwaters, sediment, and nutrients delivered to the park, although several tributary creeks are also present. The significance of Congaree National Park lies in its: (a) unique old-growth bottomland hardwood forest community associated with the swamp-like floodplain; (b) large trees, including loblolly pine (*P. taeda*), bald cypress (*T. distichum*), tupelo, sweet gum (*Liquidambar styraciflua*), American sycamore (*Platanus occidentalis*), swamp cottonwood (*Populus heterophylla*), oak (*Quercus* spp.), and American holly (*Ilex opaca*); (c) intact floodplain ecosystem; and (d) high biodiversity.

Congaree National Park has 23 known anuran species (NPSpecies 2015; Appendix A).

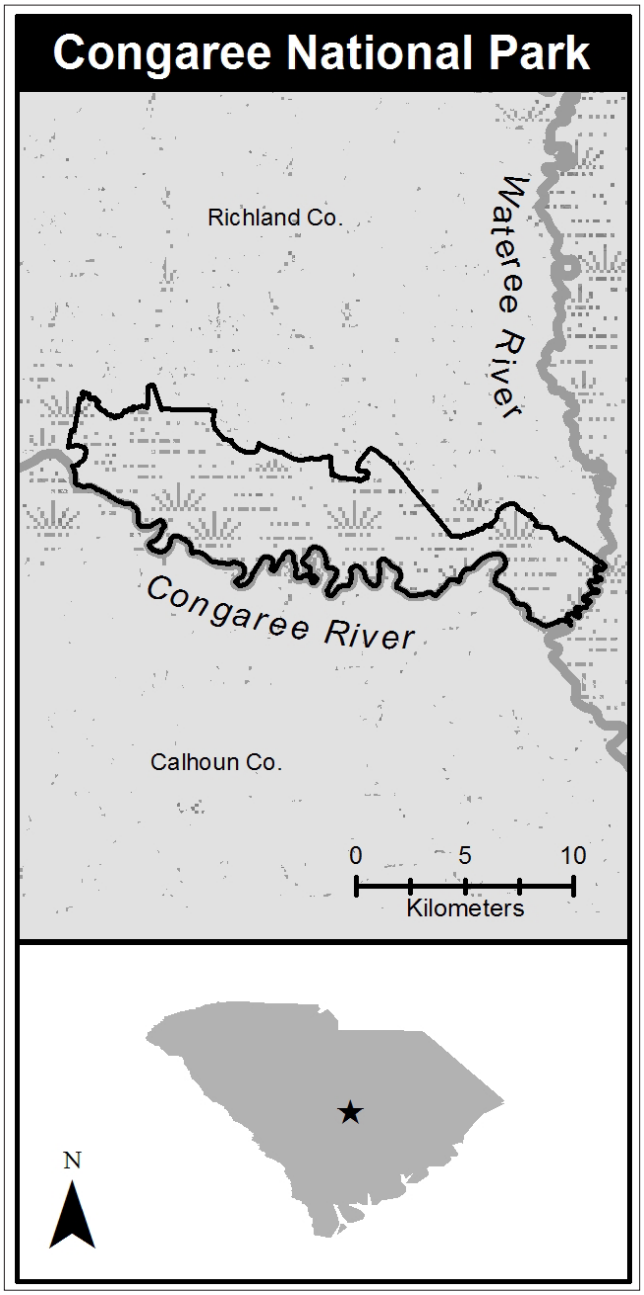


Figure 1. Location of Congaree National Park.

Monitoring Objectives

Analysis of monitoring data is based on detections of vocal anurans using automated recording devices. A detection consists of one or more observations of a species or species group during one night of monitoring at a sampling location. The Southeast Coast Network has four monitoring objectives related to anuran communities based on post-metamorphic anuran vocalization data collected from March to mid-June in non-saline wetland and upland vegetation communities in all SECN parks (Byrne et al. 2013):

- Determine the status and trends in species richness and diversity of anuran communities. Species richness and diversity estimates are based on the total number of species detected (native and non-native).
- Determine the status and trends in occupancy by anuran species. Occupancy estimates provide insight into the likelihood of encountering a specific species in a given area. The rarity, diversity, and distribution of a species or group and associated relative comparisons provide insight into the composition of the sample.
- Determine the status and trends in frequency of detection of vocal anurans. Frequency of detection is the number of nights a species or species group is observed during the sampling event at each sampling location.
- Determine trends in the vocalization phenology of select anurans with high detectability. Vocal anuran calling patterns of species with high detectability (i.e., an unbiased detectability estimate generated from the occupancy-modeling process) will be analyzed to determine the status and trends in the first and last dates on which species are detected.



Southern toad. Photo by Briana Smrekar.

Methods

Sampling Design

The sampling design and sampling-location selection is detailed in Appendix B of the SECN Vocal Anuran Community Monitoring Protocol (Byrne et al. 2013) and in the sampling-location selection Standard Operating Procedure #1.1.1 (Byrne 2012). In summary, the park's administrative boundary was used as the sampling frame to allow for park-wide inference. The sampling frame was divided into a systematic 0.5-hectare grid; the center point of each grid cell served as the potential sampling location. A spatially balanced sample was drawn from this grid using the Reversed Randomized Quadrant-Recursive Raster (RRQRR) algorithm (Theobald et al. 2007). Alternate points were used when specified selection criteria (e.g., safety issues, accessibility) were not met.

In 2014, 30 permanent sampling locations that met the selection criteria (i.e., safety and access considerations) as described in Byrne et al. (2013) were proposed for monitoring anuran communities within the park. However, due to accessibility difficulties, weather events, and other unanticipated circumstances, SECN staff were able to establish permanent plots and complete monitoring activities at only 22 of the locations (Figure 2). The remaining eight locations will be established during the next scheduled period of terrestrial monitoring activities at the park in 2017.

Taxonomic Standards

Taxonomy and nomenclature follow standards set forth in the Integrated Taxonomic Information System (ITIS; http://www.itis.gov/). The National Park Service uses the online application NPSpecies (https://irma.nps.gov/npspecies) to document "our knowledge about the occurrence and status of species on National Park Service lands," including maintenance of species lists for NPS properties. The taxonomy and nomenclature in NPSpecies is periodically updated with the most current ITIS catalog. As noted on the ITIS webpage, the system intends not to "serve as a forum for cutting-edge taxonomic classifications," but rather to use "classifications that have gained broad acceptance in the taxonomic literature and by professionals who work with the taxa."

All vocalizations are identified to the finest (i.e., lowest) resolution possible in the taxonomic hierarchy. Only vocalizations identified to the species level are used in the analyses presented herein.

Data Collection

A passive sampling technique was used to collect recordings in the field. Recordings were then manually evaluated using Song Scope software (Wildlife Acoustics, Inc.) and data were extracted to be used in the anuran community monitoring data analysis. Anuran monitoring locations are co-located with the SECN landbird community and vegetation community monitoring locations.

Automated Recording Devices

Automated recording devices (ARDs) are often used to characterize soundscapes. Recently, this technology has been applied to wildlife species monitoring efforts. The use of ARDs is advantageous in SECN parks because of (a) the high number of vocal anurans (i.e., vocalizing frogs and toads) in SECN parks, (b) the assumed broad distribution of many of these species across park lands, (c) the crepuscular and nocturnal calling behavior that predominates among the vocal anurans in SECN park units (Mohr and Dorcas 1999, Bridges and Dorcas 2000, Todd et al. 2003), (d) the safety issues for personnel conducting night-time calling surveys, and (e) the adherence of detection/non-detection data from ARDs to the monitoring objective. Further, the devices produce recordings which serve as a permanent data product that can be further analyzed as technology improves. The recordings can also be analyzed by other researchers, analyzed for other taxa, or used to quantify the soundscape.

To address some of the known influences related to imperfect detection (MacKenzie et al. 2002, MacKenzie et al. 2006), automated recording devices were deployed for 77 days to ensure detection of species present at the park as well as to assess changes in calling phenology. After the deployment period, the devices were retrieved and audio files were analyzed by SECN staff to determine the date, time, and species of all vocal anurans that were detected.

As is the case with all data collected by ARDs, the information derived is based on species' detectability. The occupancy estimates and phenology trends are based on methodology and data collection that does not account for environmental cues that initiate calling behavior (e.g., rainfall, humidity, and temperature). Additionally, while every effort is made to ensure that the recording timeframe is sufficient to encompass most vocalizing anurans, the recordings are only a portion of the time during which anurans are active. Based upon pilot monitoring efforts in the SECN from 2009–2012 and vocalization-phenology

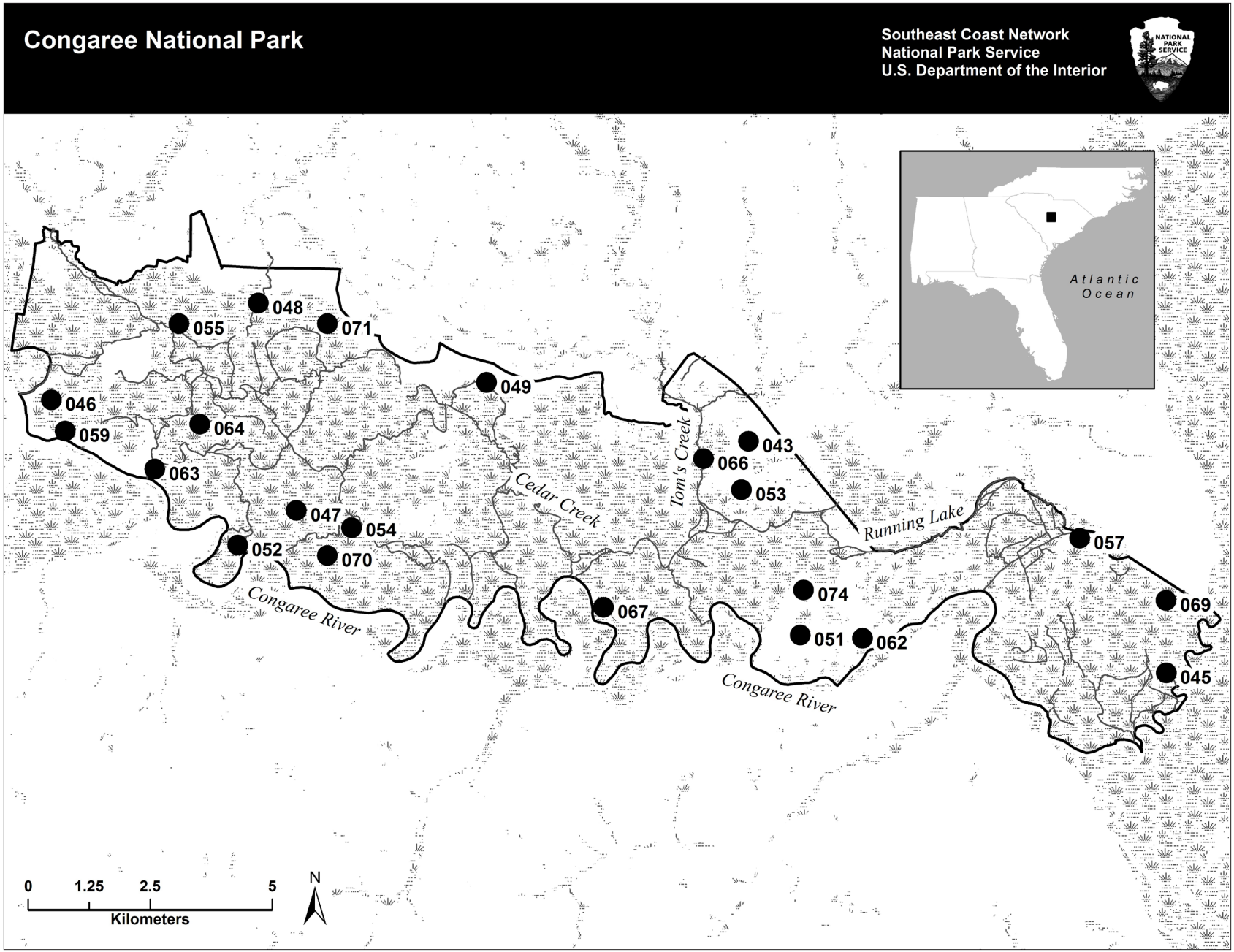


Figure 2. Spatially balanced random sampling locations at Congaree National Park, 2014.

information in the region (Dorcas and Gibbons 2008), we determined the most appropriate timeframe for deploying the ARDs in SECN parks to be March through June.

ARDs were deployed at or near the center point of each selected 0.5-hectare grid cell (i.e., the sampling location). The devices were programmed to record every four days from 18:00 (6:00 p.m.) to 06:50 (6:50 a.m.) for 30 seconds every 10 minutes. This recording schedule continued for 11 weeks (i.e., 77 days) and provided 20 distinct sampling events. ARDs were deployed at Congaree National Park from 3/21/2014 through 6/19/2014. A total of 13,278.5 minutes was recorded by all of the devices deployed. The ARD malfunctioned or was damaged by an animal and recorded only partial data at two sampling locations; one sampling event was recorded at location 052 and nine were recorded at 053. Additionally, due to prescribed fire activities in the park, the ARD at sampling location 048 had to be removed and then re-deployed during the sampling period. The unit at 048 failed to function properly after the re-deployment, resulting in a total of 16 sampling events at that location.

Species occurrences were derived from the recordings by applying various algorithms in a software environment (i.e., Song Scope), and through a manual-evaluation process implemented to maintain quality assurance and quality control standards. These processes are detailed in SOPs 1.4.2 and 1.4.21 of the SECN Vocal Anuran Community Monitoring Protocol (Byrne et al 2013).

Data Analysis

This protocol collects detection / non-detection data. In contrast to detections made from visual survey methods in which individuals can be seen, differentiated, and counted, detections from automated recording devices cannot be reliably associated with more than one individual. In general, one individual will vocalize multiple times during the survey period and is likely detected multiple times. Individual anurans vocalizing in a chorus also cannot be reliably differentiated by voice alone. Consequently, data-summary techniques do not equate one vocalization with one individual and are conducted accordingly.

Composition

Measures of community composition are often good indicators of abiotic variability, disturbance, or other stressors. Summaries related to composition include the total number of species detected (i.e., species richness), naïve occupancy, and relative detection frequency. Species richness is simply the number of native species detected.

Naïve occupancy is the percentage of the sampling locations where a species was detected at least once, without adjusting for probability of detection (i.e., detectability). Naïve occupancy is also referred to as frequency of occurrence. Naïve occupancy provides insight into the distribution of a species across the park and whether the species can be considered common or uncommon. Species with high values occur at more locations than those with low values.

Relative detection frequency uses the detection history as an index to communicate the frequency at which each species is detected relative to all other species detected in the sample. This estimate conveys information about the detectability of a species or, more specifically, a characteristic that makes a species detectable (e.g., the vocalization behavior). Species with high relative-detection frequency values are detected more frequently than species with low values. To minimize the bias inherent in this summary from the influences of detectability, vocalization behavior, sound properties, and various aspects of the automated analysis process, the estimate of relative detection frequency is derived by pooling across the detection histories and sampling locations for each species.

Distribution

Understanding changes in the distribution of amphibian species is integral to informed management of species and their requisite habitats. Changes in species distributions over time provide useful information at both the local and landscape scale regarding how species respond to large-scale influences such as changing land use, climate, hydrology, or habitat availability and condition. Shifting species distributions alter species interactions and the food-web structure, thereby producing cascading effects on ecosystem processes (Montoya and Raffaelli 2010). Distribution maps for all anuran species encountered are presented in Appendix B.

Phenology

Phenology, the periodic life-cycle events of plants and animals as they are influenced by changes in the seasons, is an increasingly useful tool in monitoring climate change and its potential effects on amphibian populations (Blaustein et al. 2001, Gibbs and Breisch 2001, Corn 2005, Parmesan 2007, Blaustein et al. 2010, Todd et al. 2011). The timing of anuran territorial and mating vocalizations can provide insight into the initiation of the breeding season for these animals, and tracking these dates may prove to be a robust method for monitoring climate change, as it presents in the southeastern United States. The Southeast Coast Network reports the earliest and latest vocalization dates of select anuran species based on their known annual vocalization pattern and the recording window of our methodology. Species should be detected during three or more park-wide sampling events during the survey year to be considered for reporting in phenology. Vocalization start dates are reported for species that typically begin to vocalize well after the start of our recording schedule in SECN parks, while species known to cease vocalizing well before our recording schedule concludes are appropriate candidates for tracking vocalization end dates (Dorcas and Gibbons 2008). Periodic synthesis reports, which will be published after multiple rounds of sampling, will summarize phenological history of anuran species detected across the Southeast Coast Network for which appropriate candidates for trend analysis are available.

Results

Composition

Due to interbreeding, and/or a similar vocalization, it was not always possible to differentiate between related species of vocalizing anurans. For this report, we have identified the Cope's gray treefrog (*Hyla chrysoscelis*), not the common gray treefrog (*Hyla versicolor*), as being present in Congaree National Park. This conclusion is based on examination of range maps (Dorcas and Gibbons 2008), and not on a microscopic examination, as would be required to definitively differentiate the two species.

We detected 13 of the 23 anuran species (56%) known to be present at Congaree National Park during 2014 monitoring activities (Table A-1). No non-native anuran species were detected.The number of species detected park-wide is expected to increase during the next monitoring effort, when the full set of 30 sampling locations will be surveyed.

Overall, species diversity was low at Congaree National Park in 2014, with three species dominating the suite of 22 sampling locations. The majority (69%) of anuran species detected at the park during this monitoring effort were found at three or fewer of the sampling locations (Table A-2). This finding indicates that, within the framework of our limited sampling design in 2014, most species occurred infrequently throughout the park.

The Cope's gray treefrog (*Hyla chrysoscelis*), detected at approximately 82% of the sampling locations in Congaree National Park, had the highest frequency of occurrence (naïve occupancy) of all anurans detected during our 2014 surveying period (Table 1). The southern toad (*Anaxyrus terrestris*) and southern leopard frog (*Lithobates sphenocephalus*) also had high naïve occupancy rates, and both were detected at over 60% of our sampling locations.

Despite the low overall species diversity at Congaree National Park in 2014, several sampling locations at the park were found to have relatively high species richness, compared to the mean of 3.3 species detected per site. Sampling locations 062 and 064 had the highest anuran species richness, with six species detected vocalizing at each site during our survey effort. Sampling locations 049 and 071 were each found to have five species present (Table A-2).

The southern toad had the highest relative detection frequency of vocalizations recorded by ARDs over the 77-day sampling period, accounting for approximately 31% of the total vocal detections (Figure 3). It was detected during 51 park-wide sampling events. Cope's gray treefrog and southern leopard frog were each detected during 38 sampling events and were responsible for just over 23% of the total vocal detections. The vocalization sample was dominated by these three species, which accounted for over 77% of vocalizations from all sampling locations in 2014. Barking treefrog (*Hyla gratiosa*), upland (southeastern) chorus frog (*Pseudacris feriarum*), eastern narrowmouth toad (*Gastrophryne carolinensis*), pickerel frog (*Lithobates palustris*), and eastern spadefoot toad (*Scaphiopus holbrookii*) were each detected on only one sampling event and at one sampling location at Congaree National Park.

New Species Records

All anuran species detected during the monitoring event were previously known to occur at Congaree National Park.

Table 1. Percentage of sampling locations where each anuran species was detected (i.e., naïve occupancy) by automated recording devices at Congaree National Park, 2014.

Anuran Species	Naïve Occupancy
Cope's Gray Treefrog	81.8
Southern Toad	77.3
Southern Leopard Frog	63.6
Green Frog	27.3
Squirrel Treefrog	13.6
Spring Peeper	13.6
Brimley's Chorus Frog	13.6
Bullfrog	13.6
Barking Treefrog	4.5
Upland (Southeastern) Chorus Frog	4.5
Eastern Narrowmouth Toad	4.5
Pickerel Frog	4.5
Eastern Spadefoot Toad	4.5
Total Locations Surveyed	**22**

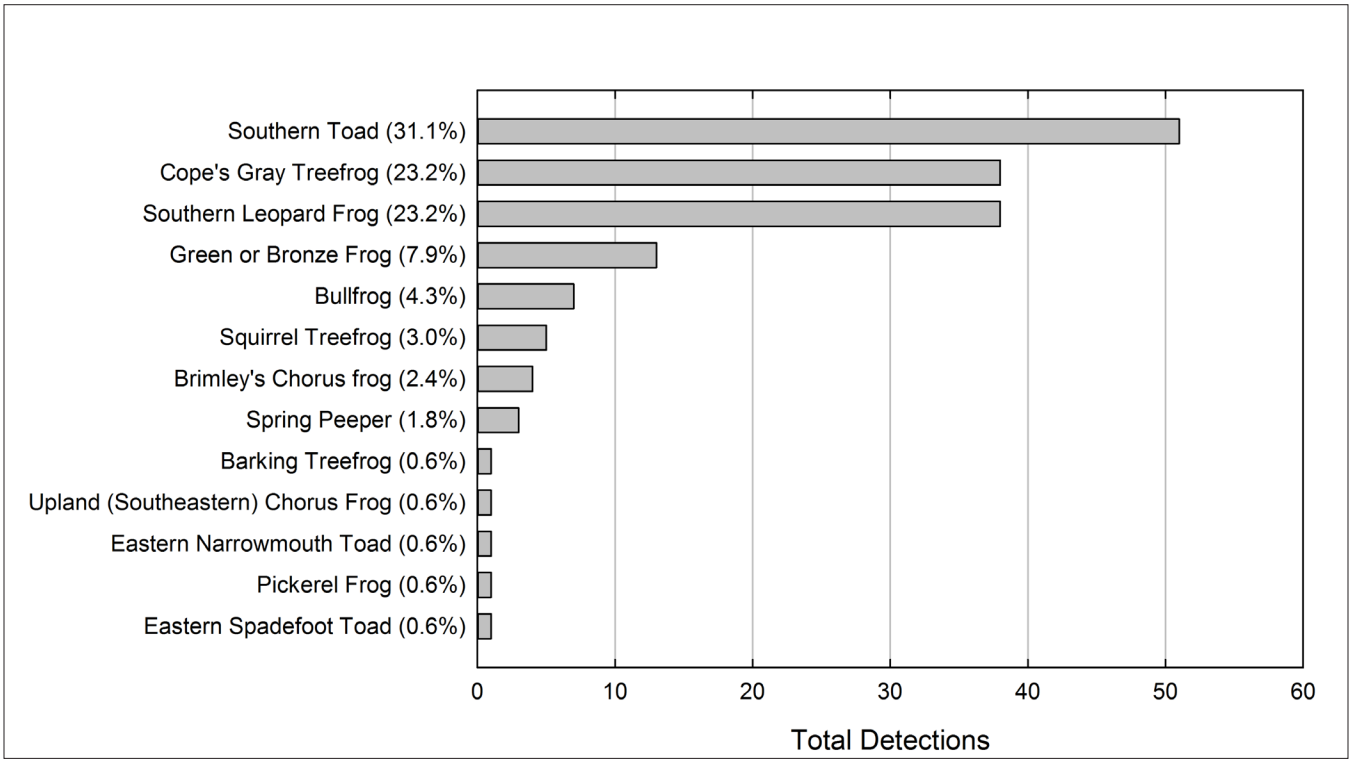


Figure 3. Number of anuran vocalization detections and percent relative detection frequency (i.e., number of species vocalizations compared to all species' vocalizations) of recorded calls during automated recording device deployment (21 March to 19 June 2014) at Congaree National Park. Based on n=164 detections.

Distribution

The southern toad, Cope's gray treefrog, and southern leopard frog were the most widely distributed anurans at Congaree National Park in 2014, and each species was detected at sampling locations throughout the north–south and east–west expanses of the park (Figures B-1, B-2, and B-12). The narrowest distributions were found for the barking treefrog, upland (southeastern) chorus frog, pickerel frog, eastern spadefoot toad, and eastern narrowmouth toad (Figures B-3, B-7, B-8, B-11, and B-13). Each of these species was found at only one sampling location within the park. Distribution maps for all anurans detected during the monitoring event are presented in Appendix B.

Phenology

Four species detected in 2014 would be appropriate candidates to determine trends in vocalization start dates. The first vocal detection of the Cope's gray treefrog occurred on 4/2/2014 and the green or bronze frog (*Lithobates clamitans*) was first detected on 4/13/2014. The bullfrog (*Lithobates catesbeianus*) was not detected until 4/27/2014, while the squirrel treefrog (*Hyla squirella*) was first detected vocalizing on 5/9/2014. Two species are appropriate for tracking vocalization end dates at Congaree National Park in 2014. The spring peeper (*Pseudacris crucifer*) was last recorded vocalizing on 3/30/2014, while the Brimley's chorus frog (*Pseudacris brimleyi*) last vocalized on 4/21/2014 (Figure 4).

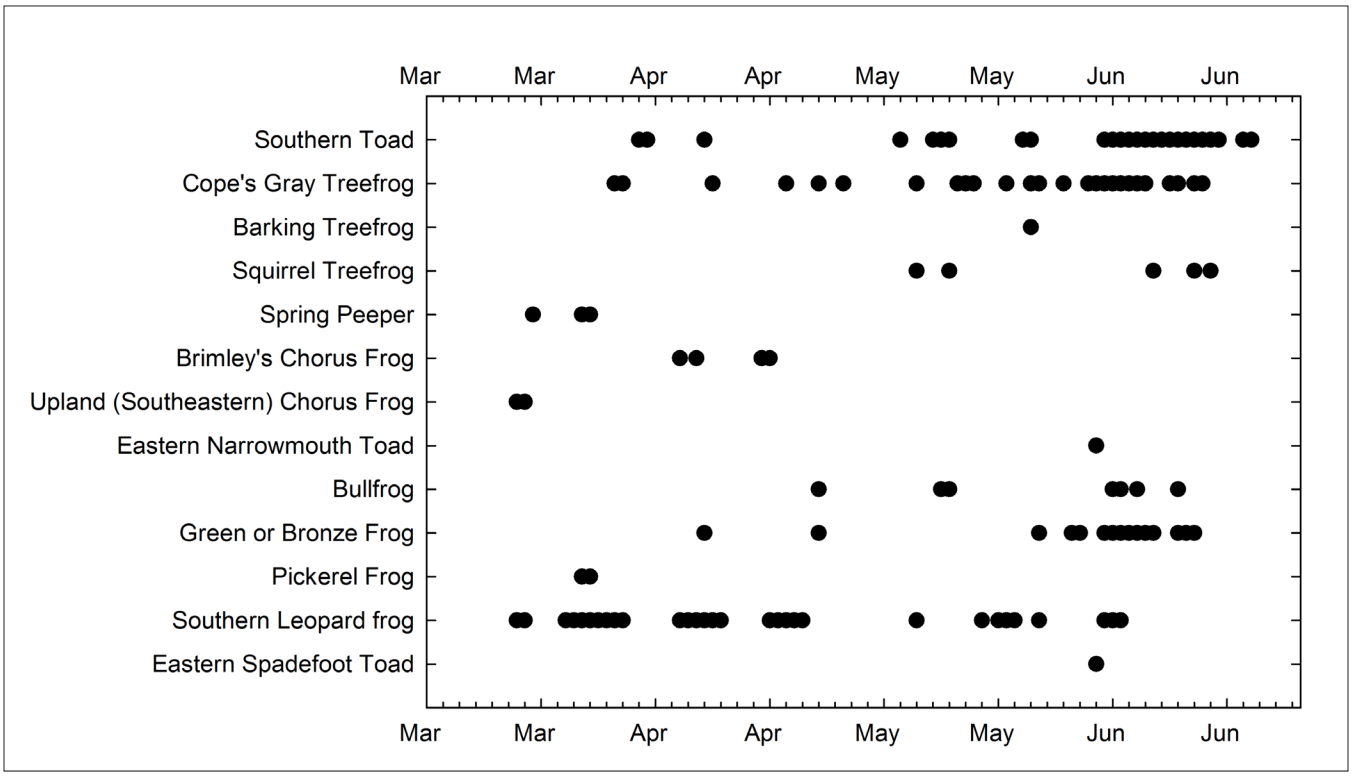


Figure 4. Vocalization phenology for species detected using automated recording devices at Congaree National Park, from 21 March to 19 June 2014. Based on n=164 detections.

Literature Cited

Blaustein, A. R., L. K. Beldon, D. H. Olson, D. M. Green, T. L. Root, and J. M. Kiesecker. 2001. Amphibian breeding and climate change. Conservation Biology 15:1804–1809.

Blaustein, A. R., S. C. Walls, B. A. Bancroft, J. L. Lawler, C. L. Searle, and S. S. Gervasi. 2010. Direct and indirect effects of climate change on amphibian populations. Diversity 2:281–313.

Bridges, A. S., and M. E. Dorcas. 2000. Temporal variation in anuran calling behavior: implications for surveys and monitoring programs. Copeia 2:587–592.

Byrne, M. W. 2012. Generating a spatially-balanced random sample with the RRQRR tool in ArcGIS 9.1 and ArcGIS 9.3.1 and applying selection criteria to select sampling locations. Southeast Coast Network Standard Operating procedure NPS/SECN/SOP—1.1.1. National Park Service, Athens, Georgia.

Byrne, M. W., J. C. DeVivo, B. D. Smrekar, L. M. Elston, C. J. Wright, and E. Thompson. 2013. Protocol for monitoring vocal anuran communities in Southeast Coast Network parks. Natural Resource Report NPS/SECN/NRR-2013-720. National Park Service, Fort Collins, Colorado.

Collins, J. P., and A. Storfer. 2003. Global amphibian declines: Sorting the hypotheses. Diversity and Distributions 9:89–98.

Corn, P. S. 2005. Climate change and amphibians. Animal Biodiversity and Conservation. 28:59–67.

Dorcas, M., and W. Gibbons. 2008. Frogs and toads of the Southeast. University of Georgia Press, Athens, Georgia.

Echternacht, A. C., and L. D. Harris. 1993. The fauna and wildlife of the southeastern United States. Pages 81–116 *in* W.H. Martin, S.G. Boyce, and A.C. Echternacht, eds., Biodiversity of the Southeastern United States: Lowland terrestrial communities. John Wiley and Sons, New York, New York, USA.

Gibbs, J. P., and A. R. Breisch. 2001. Climate warming and calling phenology of frogs near Ithaca, New York, 1900–1999. Conservation Biology 15:1175–1178.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy when detection probabilities are less than one. Ecology 83: 2248–2255.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. A. Bailey, and J. E. Hines. 2006. Occupancy modeling and estimation. Elsevier, San Diego, California, USA.

Montoya, J. M., and D. Raffaelli. 2010. Climate change, biotic interactions and ecosystem services. Philosophical Transactions of the Royal Society B 365:2013–2018.

Mohr, J. R., and M. E. Dorcas. 1999. A comparison of anuran calling patterns at two Carolina bays in South Carolina. Journal of the Elisha Mitchell Scientific Society 115:63–70.

NPSpecies—The National Park Service Biodiversity Database. Secure online version. https://irma.nps.gov/NPSpecies/Search/SpeciesList/CONG (Park list: accessed 7/29/2015).

Parmesan, C. 2007. Influences of species, latitudes, and methodologies on estimates of phonological response to global warming. Global Change Biology 13:1860–1872.

Theobald, D. M., D. L. Stevens, D. White, N. S. Urquhart, A. R. Olsen, and J. B. Norman. 2007. Using GIS to generate spatially balanced random survey designs for natural resource applications. Environmental Management 40:134–146.

Todd, M. J., R. R. Cocklin, and M. E. Dorcas. 2003. Temporal and spatial variation in anuran calling activity in the western Piedmont of North Carolina. Journal of the North Carolina Academy of Science. 119:103–110.

Todd, B. D., D. E. Scott, J. H. K. Pechmann, and J. W. Gibbons. 2011. Climate change correlates with rapid delays and advancements in reproductive timing in an amphibian community. Proceedings of the Royal Society B 278:2191–2197.

Appendix A—Anuran Species Detection Data

Table A-1. Anuran species known to occur at Congaree National Park based on the park's certified species list (NPSpecies 2015) and those detected during this sampling effort.

Scientific Name	Common Name	NPSpecies	ARD
Anaxyrus terrestris	Southern Toad	X	X
Acris crepitans	Northern Cricket Frog	X	
Acris gryllus	Southern Cricket Frog	X	
Hyla chrysoscelis	Cope's Gray Treefrog	X	X
Hyla cinerea	Green Treefrog	X	
Hyla femoralis	Pine Woods Treefrog	X	
Hyla gratiosa	Barking Treefrog	X	X
Hyla squirella	Squirrel Treefrog	X	X
Hyla versicolor	Gray Treefrog	X	
Pseudacris brimleyi	Brimley's Chorus Frog	X	X
Pseudacris crucifer	Spring Peeper	X	X
Pseudacris feriarum	Upland (Southeastern) Chorus Frog	X	X
Pseudacris nigrita	Southern Chorus Frog	X	
Pseudacris ornata	Ornate Chorus Frog	X	
Gastrophryne carolinensis	Eastern Narrowmouth Toad	X	X
Scaphiopus holbrookii	Eastern Spadefoot Toad	X	X
Lithobates catesbeianus	Bullfrog	X	X
Lithobates clamitans	Green Frog	X	X
Lithobates clamitans clamitans	Bronze Frog	X	X
Lithobates heckscheri	River Frog	X	
Lithobates palustris	Pickerel Frog	X	X
Lithobates sphenocephalus	Southern Leopard Frog	X	X
Lithobates virgatipes	Carpenter Frog	X	

Table A-2. Anuran species detected at each sampling location at Congaree National Park, 2014.

Species	43	45	46	47	48	49	51	52	53	54	55	57	59	62	63	64	66	67	69	70	71	74
Southern Toad		X		X		X	X			X	X	X	X	X	X	X	X	X	X	X	X	X
Cope's Gray Treefrog		X	X	X		X	X		X	X	X		X	X	X	X	X	X	X	X	X	X
Barking Treefrog											X											
Squirrel Treefrog						X						X		X								
Spring Peeper			X									X									X	
Brimley's Chorus Frog												X				X				X		
Upland (Southeastern) Chorus Frog			X																			
Eastern Narrowmouth Toad														X								
Bullfrog		X												X		X						
Green or Bronze Frog									X	X	X					X	X				X	
Pickerel Frog						X																
Southern Leopard Frog		X	X	X		X	X		X	X			X	X		X	X		X		X	X
Eastern Spadefoot Toad				X																		

Appendix B—Distribution Maps for Anuran Species Encountered

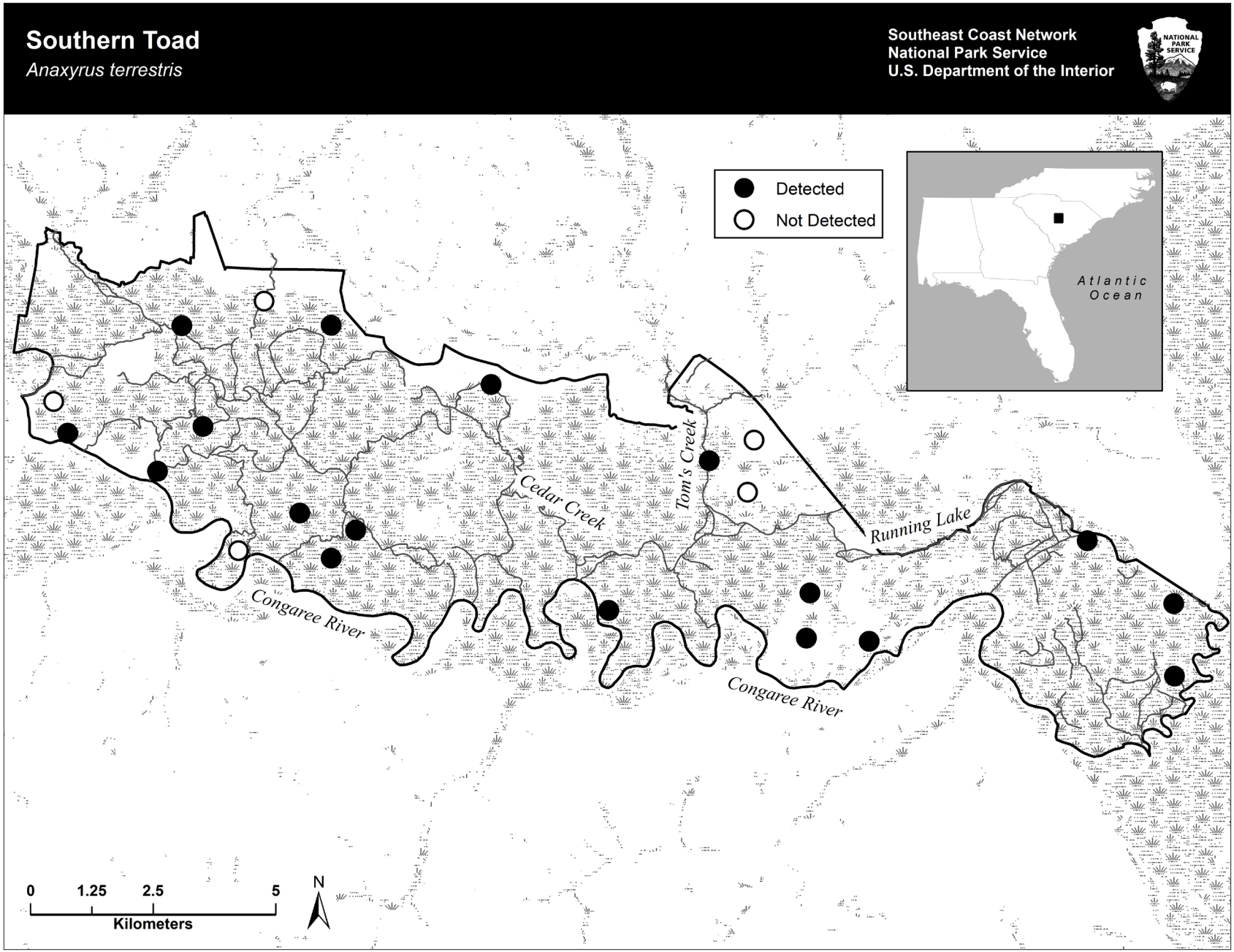


Figure B-1. Sampling locations where southern toad (*Anaxyrus terrestris*) was detected at Congaree National Park, 2014.

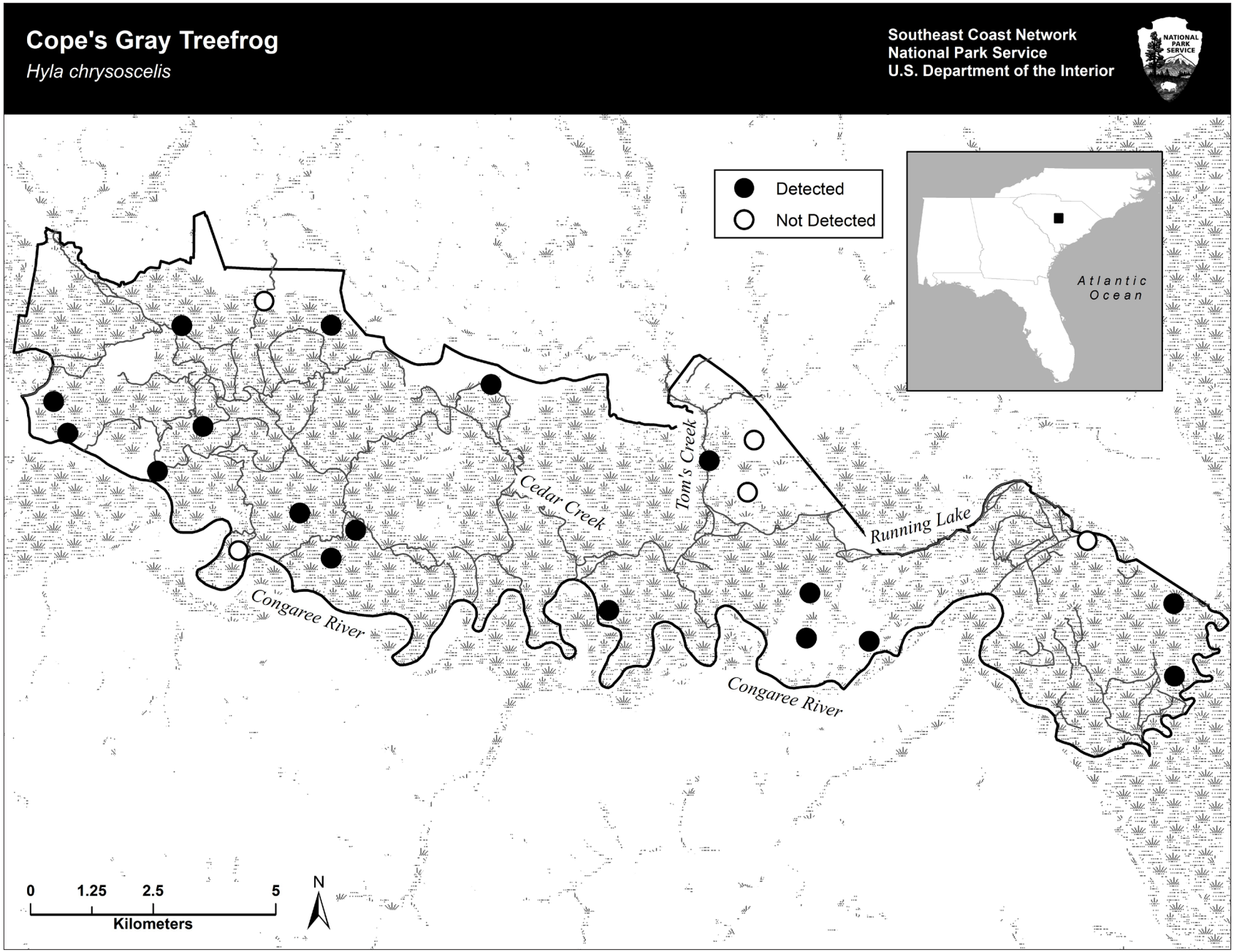


Figure B-2. Sampling locations where Cope's gray treefrog (*Hyla chrysoscelis*) was detected at Congaree National Park, 2014.

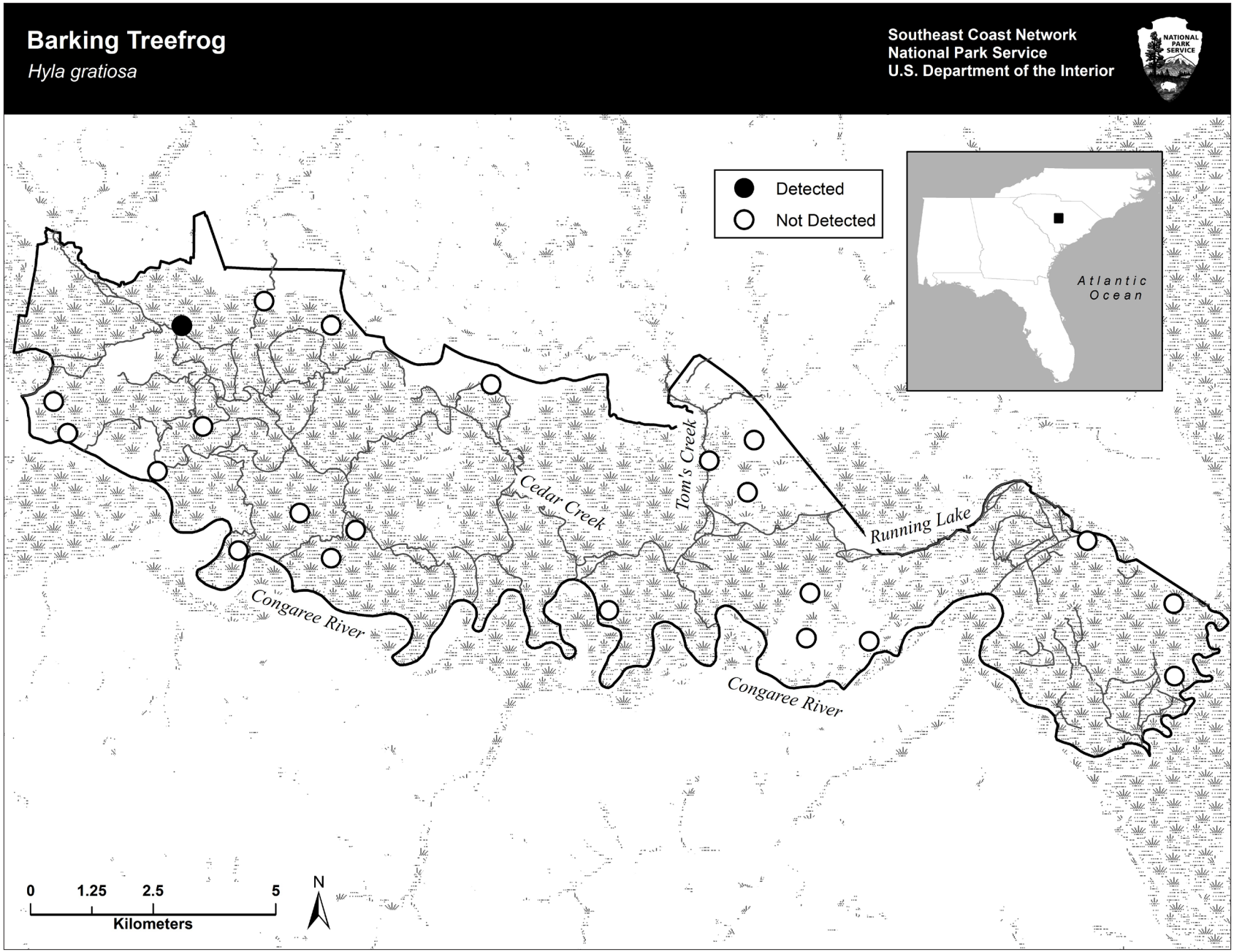


Figure B-3. Sampling location where barking treefrog (*Hyla gratiosa*) was detected at Congaree National Park, 2014.

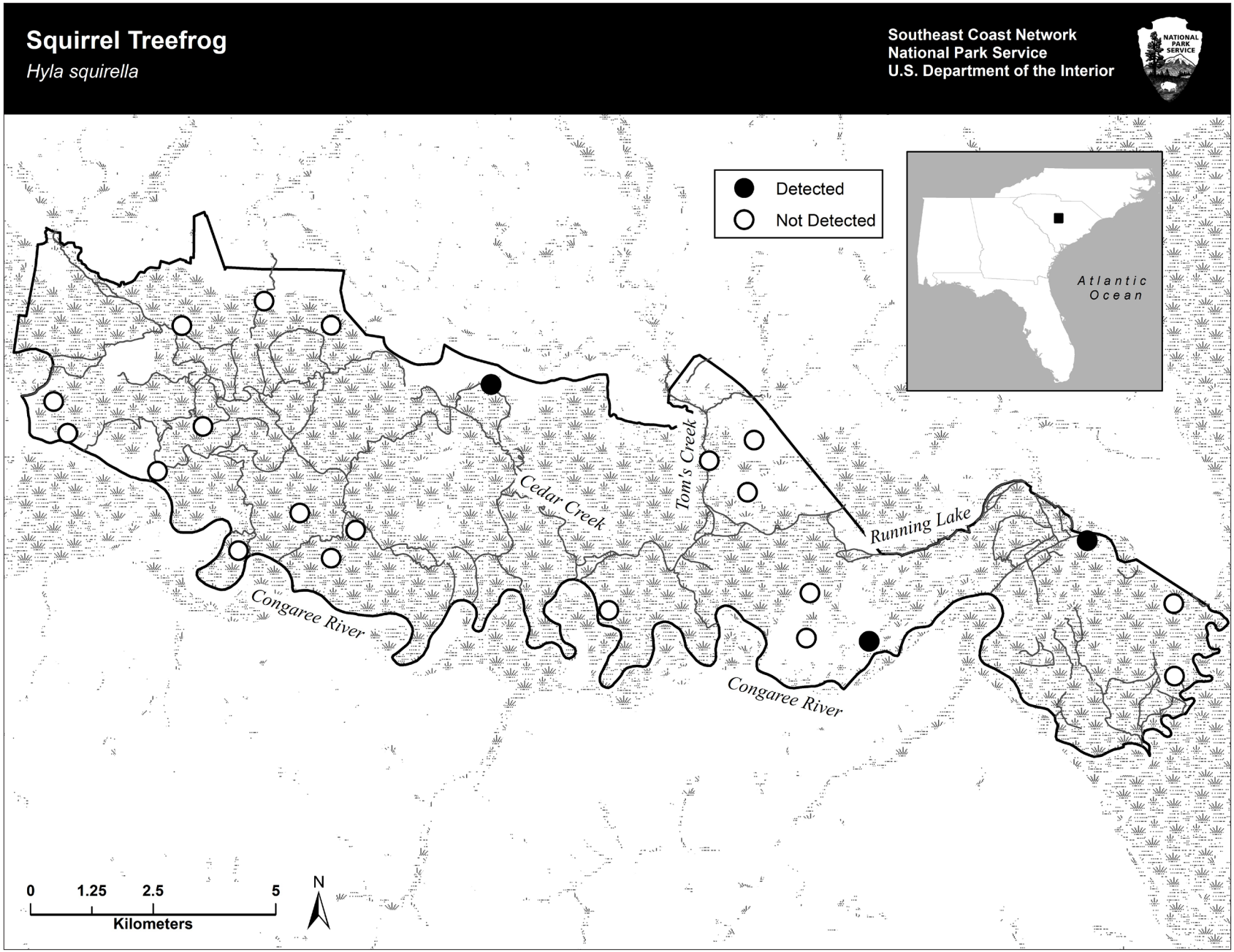


Figure B-4. Sampling locations where squirrel treefrog (*Hyla squirella*) was detected at Congaree National Park, 2014.

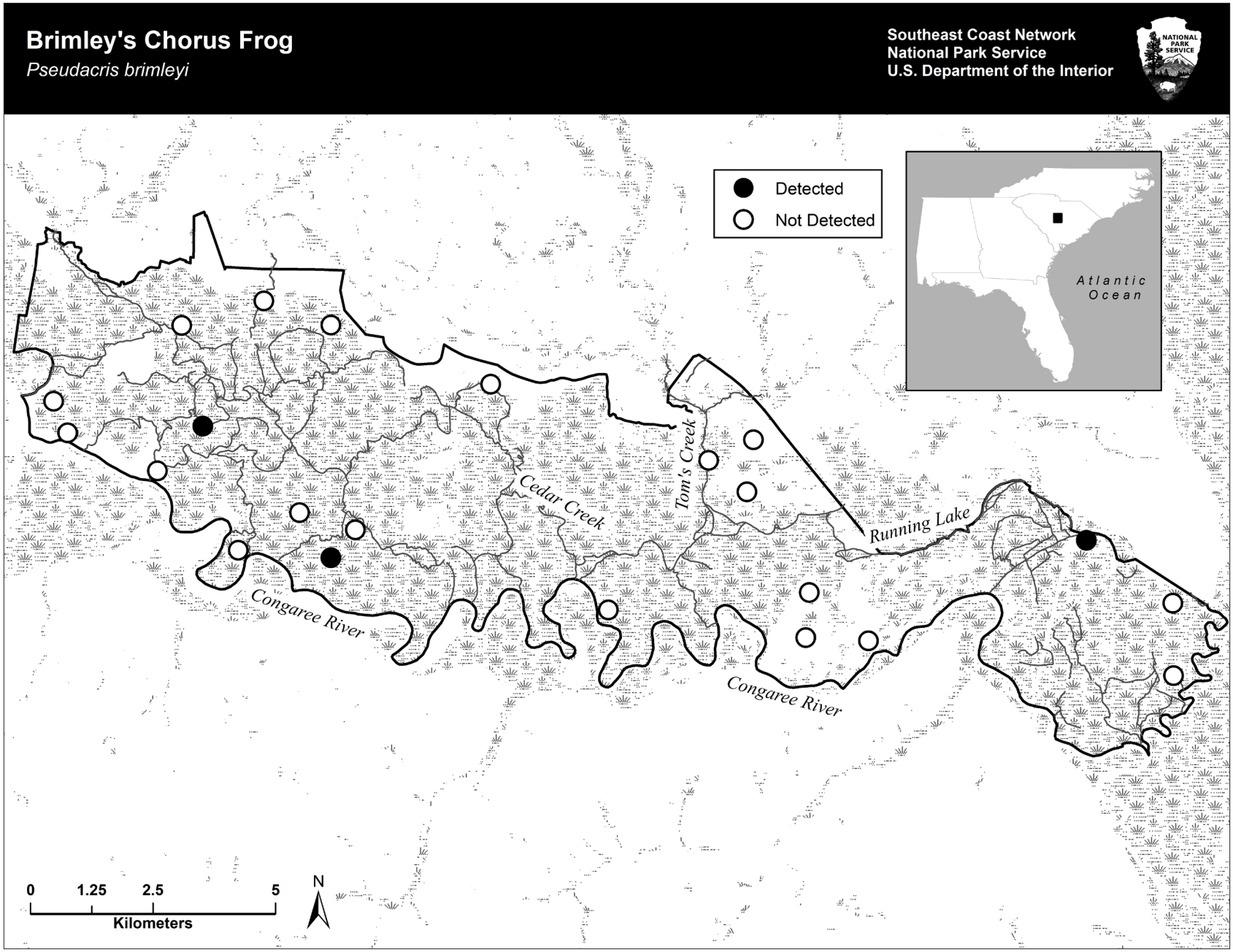


Figure B-5. Sampling locations where Brimley's chorus frog (*Pseudacris brimleyi*) was detected at Congaree National Park, 2014.

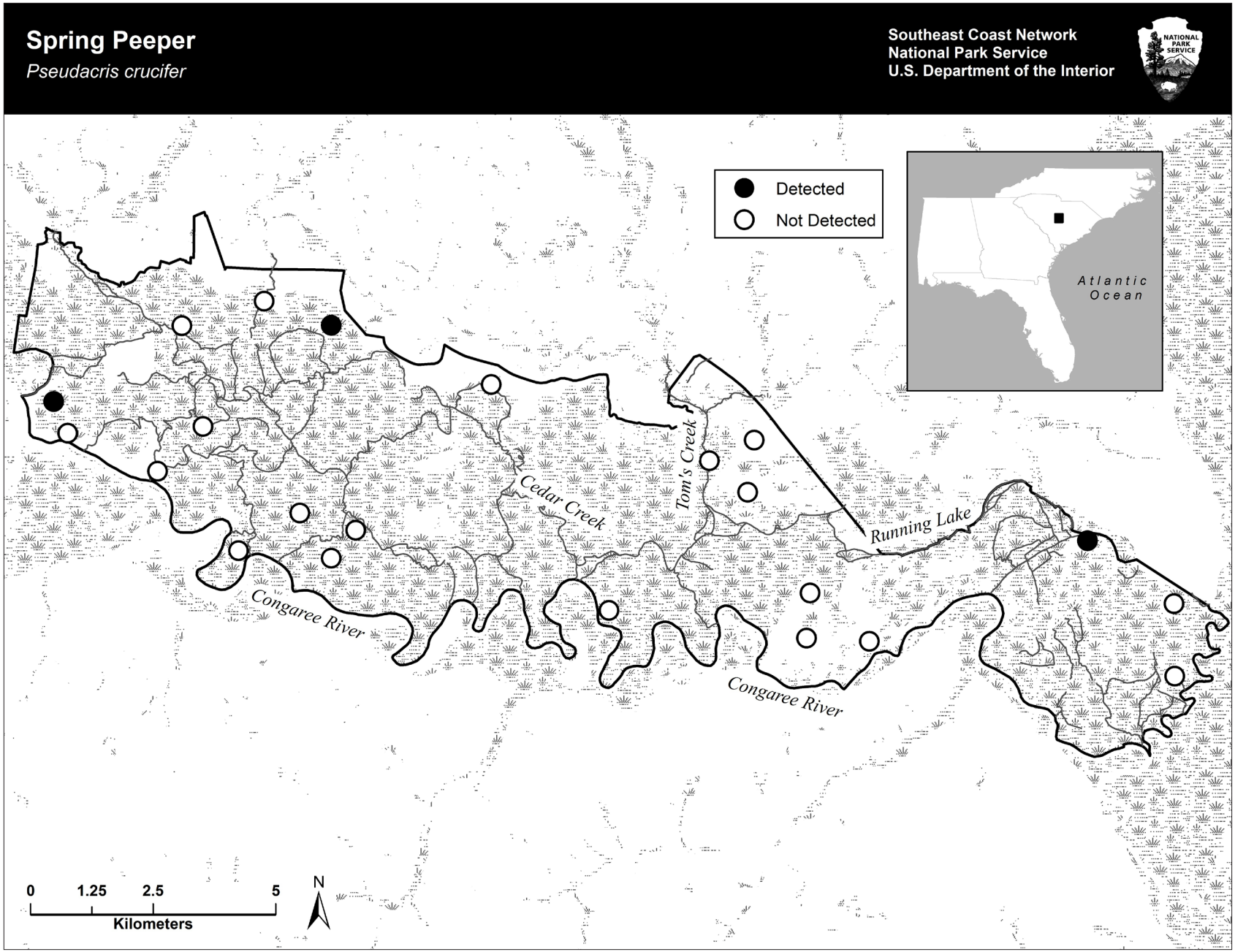


Figure B-6. Sampling locations where spring peeper (*Pseudacris crucifer*) was detected at Congaree National Park, 2014.

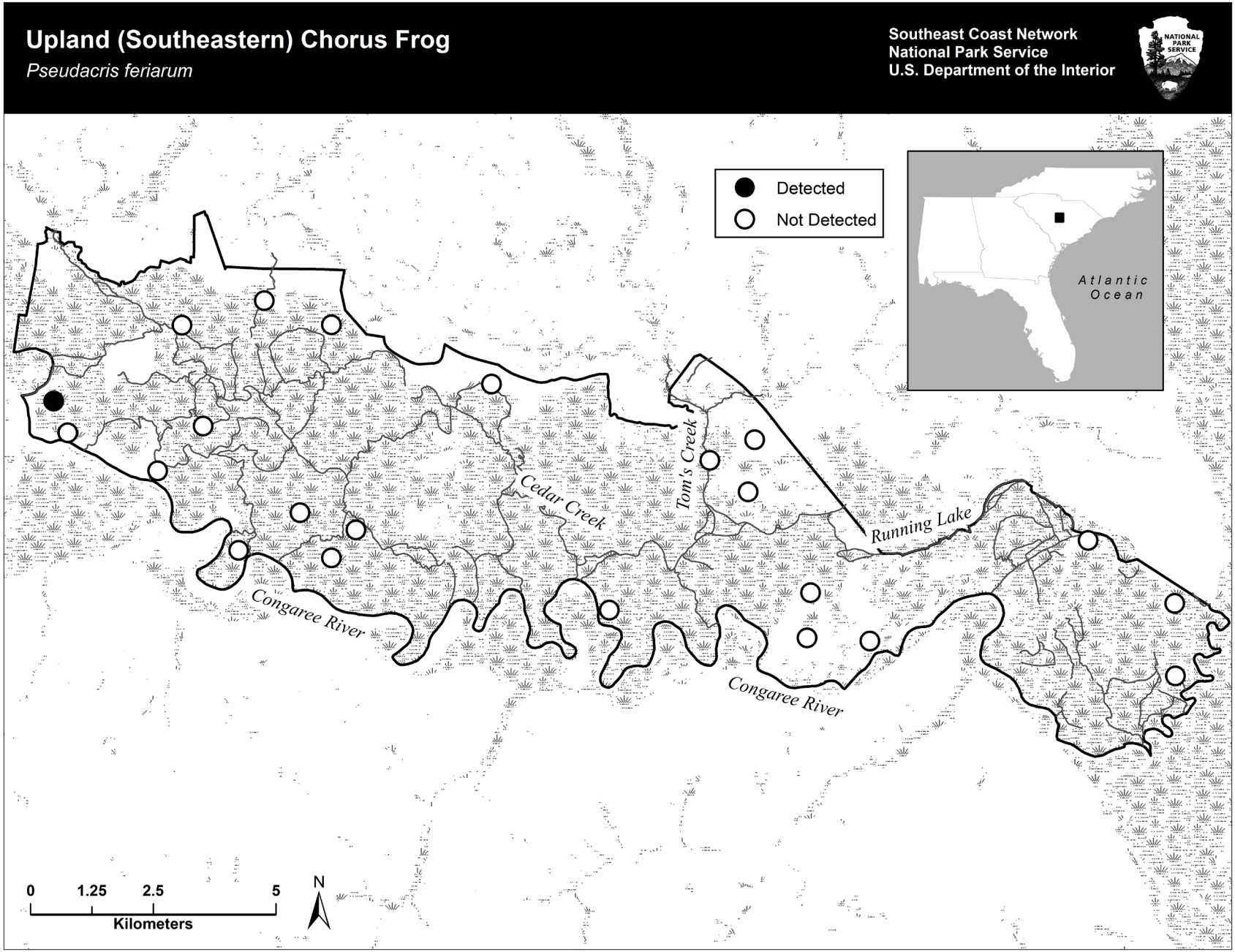


Figure B-7. Sampling location where upland (southeastern) chorus frog (*Pseudacris feriarum*) was detected at Congaree National Park, 2014.

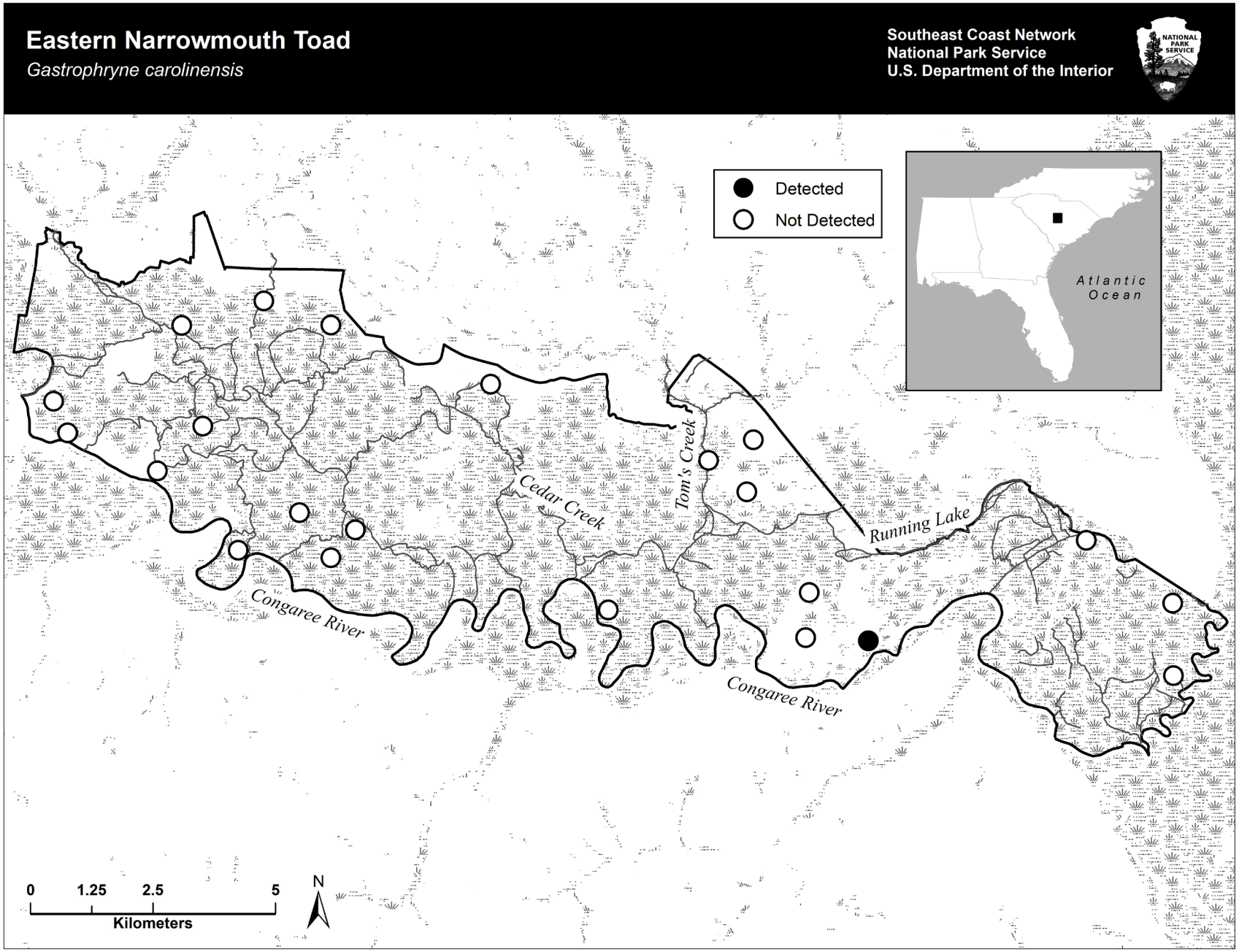


Figure B-8. Sampling location where eastern narrowmouth toad (*Gastrophryne carolinensis*) was detected at Congaree National Park, 2014.

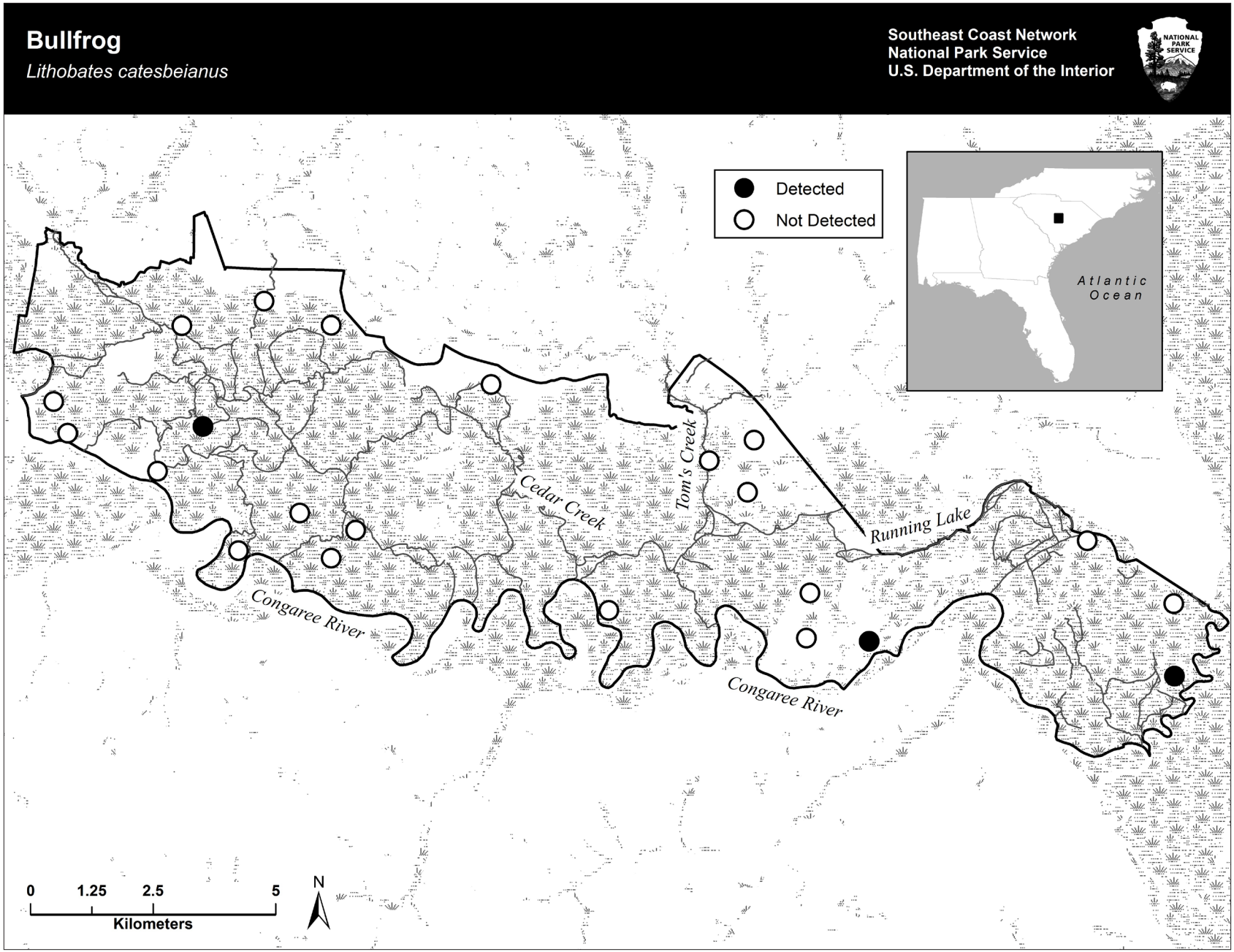


Figure B-9. Sampling locations where bullfrog (*Lithobates catesbeianus*) was detected at Congaree National Park, 2014.

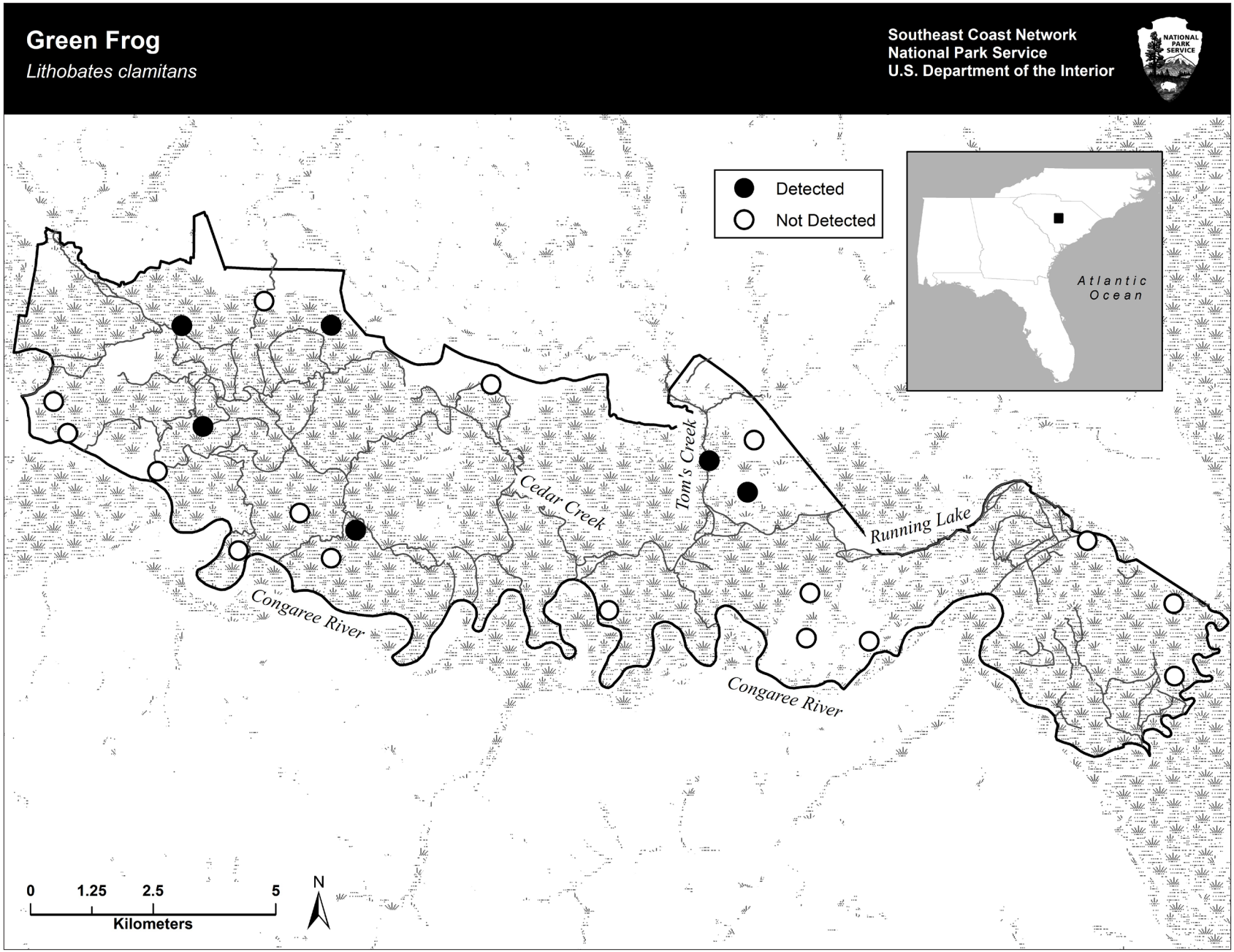


Figure B-10. Sampling locations where green frog (*Lithobates clamitans*) was detected at Congaree National Park, 2014.

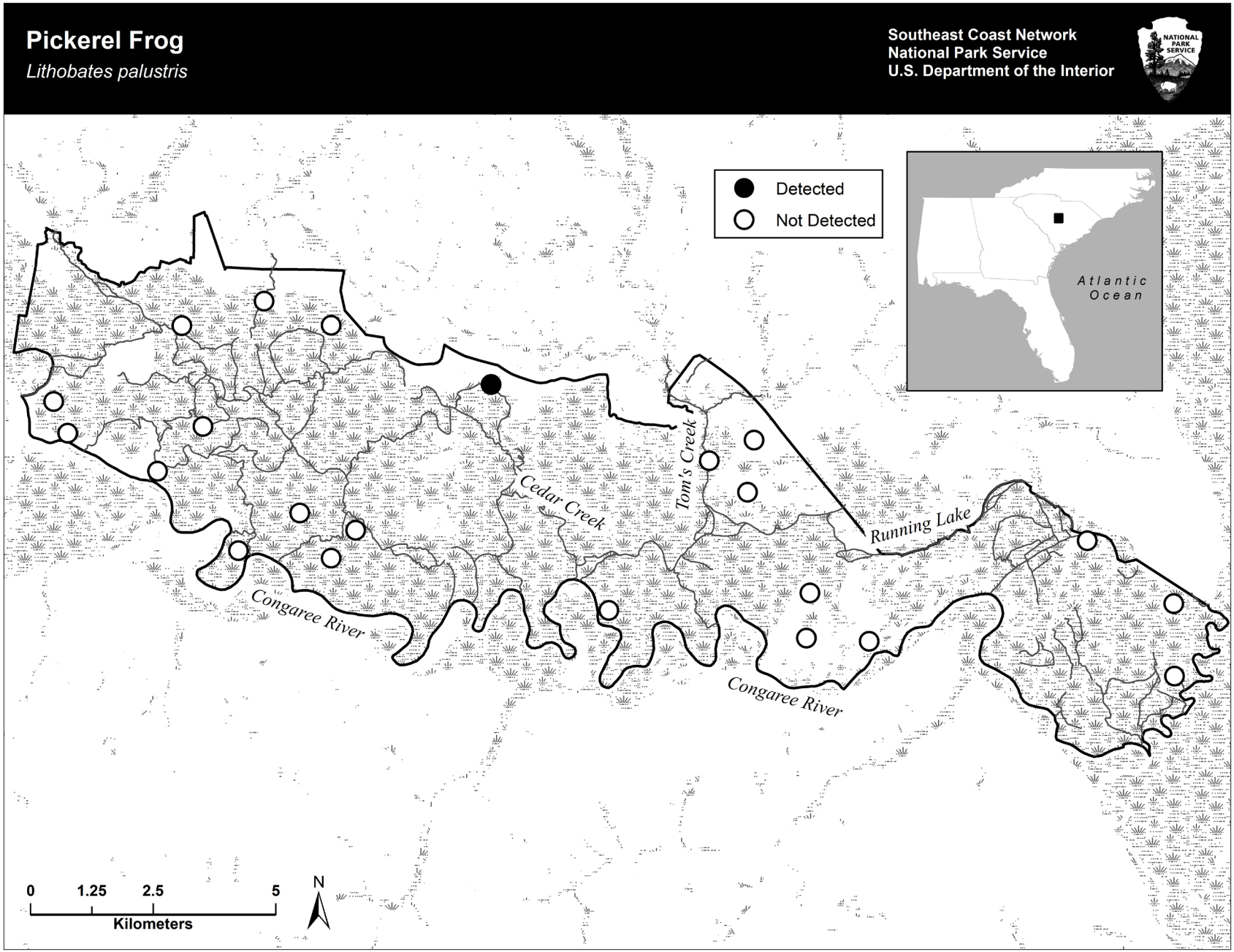


Figure B-11. Sampling location where pickerel frog (*Lithobates palustris*) was detected at Congaree National Park, 2014.

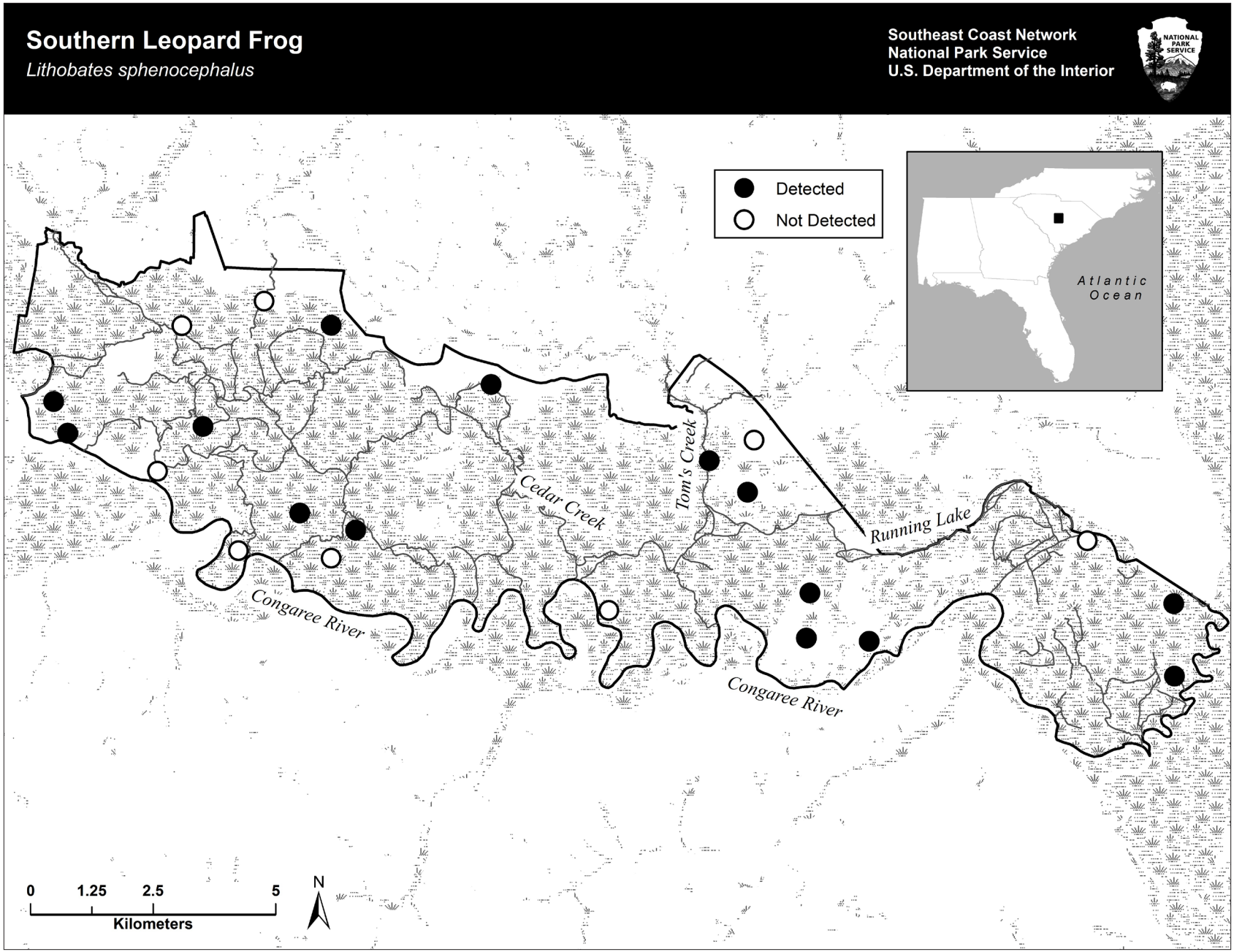


Figure B-12. Sampling locations where southern leopard frog (*Lithobates sphenocephalus*) was detected at Congaree National Park, 2014.

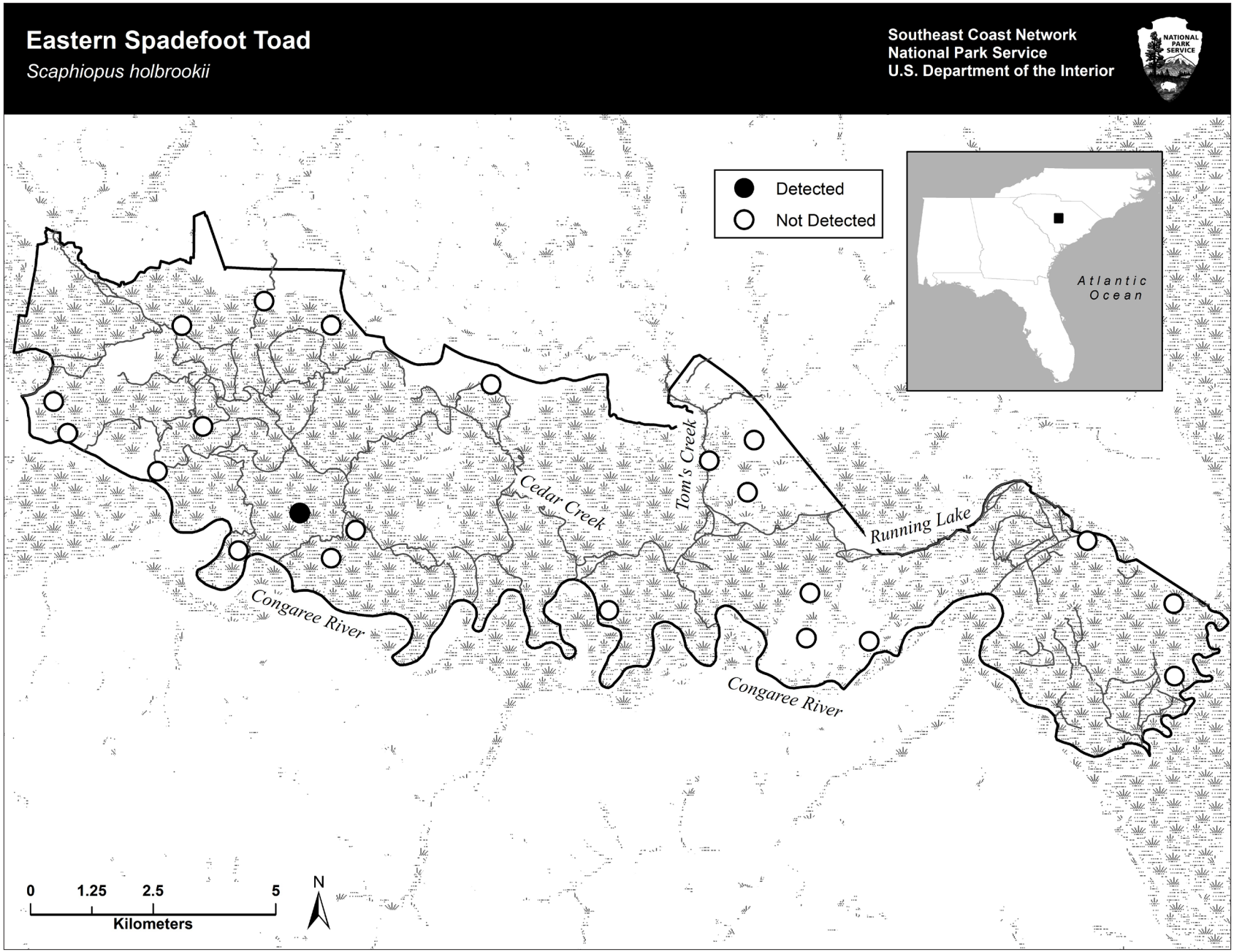


Figure B-13. Sampling location where eastern spadefoot toad (*Scaphiopus holbrooki*) was detected at Congaree National Park, 2014.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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